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UNITED STATES DEPARTMENT OF AGRICULTURE
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OBSERVATIONS OF THE EFFECT OF PACKAGING TEMPERATURE OF NONFAT DRY MILK ON INSECTS IN THE CONTAINERS

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SUMMARY

Four standard fiberboard drums were infested with free and caged larvae of Trogoderma inclusum and the black carpet beetle, Attagenus piceus, during commercial packaging, to determine whether the heat of the nonfat dry milk is sufficient to kill all the insects that might be present in the containers. Two of the drums were filled with dried milk at 135° F. and two with milk at 160°. All drums were opened 1 week later and the numbers of live, moribund, and dead larvae recovered at the various sites of exposure were determined.

The heat from dried milk packaged at even the higher temperature did not kill all the insects in drums or liners at the time of packaging. The added factor of crushing, from the weight of the milk itself, did not produce complete insect mortality. However, direct exposure to milk at the higher temperature is apparently fatal.

It is necessary, therefore, that every precaution be taken to make certain all containers and liners are insect-free before they are used for packaging nonfat dry milk.

BACKGROUND AND PURPOSE OF STUDY

Previous research to investigate the ability of Trogoderma inclusum and the black carpet beetle, Attagenus piceus, to invade sealed drums and to penetrate the polyethylene liners after dried milk has been in storage

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1/ This is one of the field stations of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture. J. E. Gorman, of this laboratory, assisted in these tests.

2/ Approved for publication by the Director of Wisconsin Agricultural Experiment Station.

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indicated that a properly sealed drum is a relatively effective barrier against such invasion. It is widely felt in industry that the heat of the powdered milk at the time of packaging is sufficiently high to kill any insects that might be in drums or liners prior to sealing. A test was therefore conducted to explore this question and try to learn more about possible sources of insect infestation in stored nonfat dry milk.

METHODS AND MATERIALS

Four drums of powdered milk were infested with insects during filling and then sealed according to present commercial practice. Two methods of insect exposure were used. In the first, 10 black carpet beetle and 10 *Trogoderma inclusum* larvae of various ages were placed free in the different exposure sites; in the second, a similar number of insects were confined to the exposure site by means of wire cages. The latter were constructed by soldering 100-mesh brass screen cylinders ½ inch in diameter and plugging either end with wooden dowling of similar size. The plugs were approximately 3/4 inch apart, producing an insect confinement volume of approximately 1 cubic inch. The ends of all cages were also sealed with masking tape and metal wire.

The selected sites of insect exposure in each drum were as follows (fig. 1):

A. Between the kraft liner and drum:
   1. In the center of the bottom of the drum.
   2. On the bottom edge of the drum.
   3. On the side of the drum, half-way between the upper and lower surfaces of the milk.
   4. On the side of the drum, at the upper surface of the milk.
   5. On the interior surface of the metal rim of the upper edge of the drum.

B. Between the kraft and polyethylene liners in positions A-2, 3, and 4.

C. In the milk:
   1. In the center of the upper surface.
   2. In the center, half-way between the upper and lower surfaces.

With the exception of A-1 and A-5, a similar number of free insects were also placed in the positions described. However, those exposed between the drum and liners and between the liners were placed on the opposite side of the drum from those positions in which the cages were placed. The free larvae exposed in the center of the bottom of the drum were placed inside the polyethylene rather than outside the kraft liner.

The dried milk was obtained from two sites in the sifting and packaging operation; first, directly from the sifter; and second, after storage for a short period of time in a hopper. The initial temperature of the milk

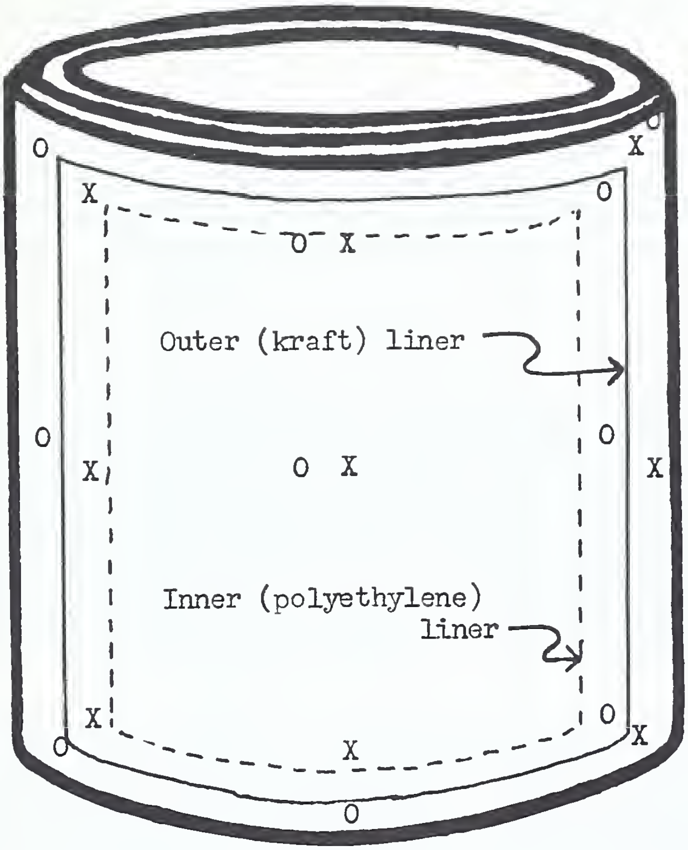

Figure 1.--Exposure sites for larvae of Trogoderma inclusum and the black carpet beetle, Attagenus piceus, placed in drums at the time of filling with hot powdered milk. O - caged insects; X - free insects.

packaged at the first site was approximately 160° F., at the latter 135°. Either of these temperatures should equal or exceed that of most dried milk at the time of packaging.

All free and caged insects to be exposed in the bottom of drums and liners were placed on the exposure site approximately 5 minutes before the milk was introduced; the remaining insects were placed in the drum as it was being filled. After the drums were filled, the drum liners were tied and a final cage of insects was taped to the inner surface of the metal edge surrounding the drum.

The drums were sealed, stored for 3 days in the producing plant, and then transferred to a local warehouse. After 1 week, they were opened and inspected. The free insects recovered at the various exposure sites were placed in petri dishes and returned, along with the cages, to the laboratory, and the number of live, moribund, and dead insects were determined.

RESULTS

A significant number of both free and caged insects survived exposure in the drums filled with milk at either temperature (table 1). At 135° F., approximately 75 percent of the total larvae of either species exposed in cages were still alive after 1 week, but at 160° only 53 percent of the *Trogoderma inclusum* and 35 percent of the black carpet beetle larvae were alive. Approximately 46 percent of the free black carpet beetle and 38 percent of the *Trogoderma* larvae exposed in drums filled with milk at 135° and approximately 25 percent of the free larvae of either species exposed at 160° were alive.

No free or caged black carpet beetle larvae and no caged *Trogoderma* larvae survived exposure in the center of the upper surface of milk packaged at either temperature. However, 1 free *Trogoderma* larva on the upper surface and 5 free larvae in the center of milk packaged at 135° F. were found alive. No live insects were observed in these latter positions in the milk packaged at 160°.

Both live black carpet beetle and *Trogoderma* larvae were recovered from the bottom of the inner surface of the polyethylene liner used for storing milk packaged at 135° F., whereas in the drum storing milk packaged at the higher temperature only *Trogoderma* were found alive. The folds of polyethylene on the bottom of the milk apparently furnished adequate insulation against the heat.

In the drums filled with milk at 160° F., live *Trogoderma* larvae were recovered from most of the cages placed between the kraft and polyethylene liners, but all black carpet beetle larvae were moribund or dead. At 135°, live insects of both species were recovered from the cages placed in similar positions.

Table 1.--Average number of *Trogoderma inclusum* and black carpet beetle larvae, *Attagenus piceus*, alive after a 1-week exposure of 10 larvae of each species in each of various positions in drums filled with dried milk at 135° and 160°F. (tests conducted in duplicate, total of 20 insects in each location).

Location of test insects	Milk at 135° F.				Milk at 160° F.			
	Caged insects		Free insects		Caged insects		Free insects	
	A. piceus	*T. inclusum*	*A. piceus*	*T. inclusum*	*A. piceus*	*T. inclusum*	*A. piceus*	*T. inclusum*
	Number	Number	Number	Number	Number	Number	Number	Number
Between kraft liner and drum:								
Side at top	9.0	9.5	2.0	2.0	10.0	9.5	2.5	3.5
Side at center	10.0	9.5	10.0	2.0	0	.5	3.5	3.0
Side at bottom	10.0	10.0	9.5	6.0	10.0	9.5	12.5	7.5
Center at bottom	10.0	9.5	-	-	5.0	9.0	-	-
Between kraft and polyethylene liner:								
Side at top	10.0	9.5	1.5	2.5	0	7.5	.5	3.5
Side at center	5.0	9.0	6.0	5.5	0	1.0	.5	1.0
Side at bottom	10.0	9.0	9.0	9.5	0	7.5	3.0	5.0
In milk:								
Center at top	0	0	0	.5	0	0	0	0
Center at center	0	0	0	2.5	0	0	0	0
Center at bottom	-	-	3.5	4.0	-	-	0	1.0
On drum rim	10.0	10.0	-	-	10.0	8.5	-	-

When the cages were placed at the upper or lower surface of the milk, most of the *Trogoderma* larvae exposed between the liners or between the outer liner and drum of milk packaged at the higher temperature were still alive, whereas most of the larvae exposed in the cages placed midway between the upper and lower surfaces were moribund or dead. Apparently heat loss or protection by kraft or polyethylene folds is usually not adequate in the latter area for insect survival.

With the exception of three squashed *Trogoderma* larvae, all insects exposed in the cages taped to the inner surface of the metal rim of the upper edge of the drum were alive.

A significantly high percentage of the mortality of free larvae in both drums appeared to be due to crushing rather than heat, but no attempt was made to determine the cause of death.

The relatively high number of free *Trogoderma* larvae not recovered in some drums during the inspection was undoubtedly due, for the most part, to our failure to find those that had been badly squashed onto the surface of the kraft liner. The color of the insects and that of the bag were nearly identical. In addition, many free insects were not found at the original exposure site, because they slid down the drum when the liners were pulled aside. Most of these larvae, however, were recovered from the bottom of the drums and liners.

A significant difference in larval mortality occasionally was observed in replicated exposure cages. This again may be due to a fold in the polyethylene or kraft liner which afforded additional insulation against the milk itself.

DISCUSSION

The heat of nonfat dry milk packaged at temperatures as high as 160° F. does not appear to be adequate for killing all insects which might be present in drums or liners at the time of filling unless the insects come in direct contact with the milk. At 135°, *Trogoderma* appears to be able to withstand even the latter condition.

Apparently both kraft and polyethylene liners afford a number of creases and folds along the side and bottom of drums which insulate the insects against heat. In addition, the kraft liner exhibits a cushioning effect which appears to offer significant protection against crushing.

It is essential that liners and drums be free of insects at the time of packaging, since the heat of the dry milk cannot be relied on for killing infestations. Eliminating the kraft liner and increasing the thickness of the polyethylene liner may reduce the number of protected areas and result in a greater insect mortality.

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